SAVING ENERGY
LEARNING & CONSERVING
Teacher Guide

These activities explore energy use and conservation using the school as a learning laboratory.

EFFICIENCY CONSERVATION

GRADE LEVEL
7–12

SUBJECT AREAS
Science
Social Studies
Math
Language Arts
Technology

NEED
2009-2010
Putting Energy into Education

NEED Project PO Box 10101 Manassas, VA 20108 1-800-875-5029 www.NEED.org

Teacher Advisory Board

Teacher Advisory Board Vision Statement

NEED Mission Statement

The mission of the NEED Project is to promote an energy conscious and educated society by creating effective networks of students, educators, business, government and community leaders to design and deliver objective, multi-sided energy education programs.

In support of NEED, the national Teacher Advisory Board (TAB) is dedicated to developing and promoting standards-based energy curriculum and training.

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TABLE OF CONTENTS

Learning & Conserving is designed to be the classroom education component of a total energy management plan for secondary schools. An energy management plan would also include a comprehensive energy audit, retrofitting and training of the building manager, administrators, and maintenance staff.

Learning & Conserving Kit includes:

2 Lamps
1 Incandescent Bulb
1 Compact Fluorescent Bulb
2 Kill A Watt™ Monitors
1 Indoor/Outdoor Thermometer
1 Light Meter
1 Flicker Checker
1 Waterproof Digital Thermometer
1 Digital Hygrometer/Thermometer Pen
1 Class Set of Student Guides (30)

Cost: $300

Endorsed by NSBA National School Boards Association

NEED Putting Energy into Education

Correlations to National Science Standards

(Bolded standards are emphasized in the unit.)

UNIFYING CONCEPTS AND PROCESSES

Systems, Order, and Organization

The goal of this standard is to think and analyze in terms of systems, which will help students keep track of mass, energy, objects, organisms, and events referred to in the content standards.

Evidence, Models, and Explanation

Evidence consists of observations and data on which to base scientific explanations. Using evidence to understand interactions allows individuals to predict changes in natural and designed systems.

Scientific explanations incorporate existing scientific knowledge and new evidence from observations, experiments, or models into internally consistent, logical statements.

Change, Constancy, and Measurement

Energy can be transferred and matter can be changed. Nevertheless, when measured, the sum of energy and matter in systems, and by extension in the universe, remains the same.

Changes can occur in the properties of materials, position of objects, motion, and form and function of systems. Interactions within and among systems result in change. Changes in systems can be quantified and measured. Mathematics is essential for accurately measuring change.

Different systems of measurement are used for different purposes. An important part of measurement is knowing when to use which system.

INTERMEDIATE (GRADES 5-8) CONTENT STANDARD A: SCIENCE AS INQUIRY

Abilities Necessary to do Scientific Inquiry

Identify questions that can be answered through scientific inquiry.

Design and conduct a scientific investigation.

Use appropriate tools and techniques to gather, analyze, and interpret data.

Develop descriptions, explanations, predictions, and models using evidence.

Think critically and logically to make the relationships between evidence and explanations.

Recognize and analyze alternative explanations and predictions.

Communicate scientific procedures and explanations.

Use mathematics in all aspects of scientific inquiry.

INTERMEDIATE CONTENT STANDARD B: PHYSICAL SCIENCE

Transfer of Energy

Energy is a property of many substances and is associated with heat, light, electricity, mechanical motion, sound, nuclei, and the nature of a chemical.

Energy is transferred in many ways.

The sun is the major source of energy for changes on the earth's surface. The sun loses energy by emitting light. A tiny fraction of that light reaches earth, transferring energy from the sun to the earth. The sun's energy arrives as light with a range of wavelengths.

INTERMEDIATE CONTENT STANDARD F: SCIENCE IN PERSONAL AND SOCIAL PERSPECTIVES

Natural Hazards

Human activities can induce hazards through resource acquisition, urban growth, land-use decisions, and waste disposal.

Hazards can present personal and societal challenges because misidentifying the change or incorrectly estimating the rate and scale of change may result in either too little attention and significant human costs or too much cost for unneeded preventive measures.

Risks and Benefits

Students should understand the risks associated with natural hazards, chemical hazards, biological hazards, social hazards, and personal hazards.

Students can use a systematic approach to thinking critically about risks and benefits.

Important personal and social decisions are made based on perceptions of benefits and risks.

SECONDARY (GRADES 9-12) CONTENT STANDARD B: PHYSICAL SCIENCE

Conservation of Energy and the Increase in Disorder

The total energy of the universe is constant. Energy can be transferred by collisions in chemical and nuclear reactions, by light waves and other radiations, and in many other ways. However, it can never be destroyed. As these transfers occur, the matter involved becomes steadily less ordered.

All energy can be considered to be either kinetic energy—the energy of motion; potential energy—which depends on relative position; or energy contained by a field, such as electromagnetic waves.

Interactions of Energy and Matter

In some materials, such as metal, electrons flow easily, whereas in insulating materials such as glass, they can hardly flow at all.

SECONDARY STANDARD C: LIFE SCIENCE

The Interdependence of Organisms

Humans modify ecosystems as a result of population growth, technology, and consumption. Human destruction of habitats through harvesting, pollution, atmospheric changes, and other factors is threatening global stability, and if not addressed, ecosystems will be irreversibly affected.

SECONDARY STANDARD F: SCIENCE IN PERSONAL AND SOCIAL PERSPECTIVES

Natural Resources

Human populations use resources in the environment to maintain and improve their existence.

The earth does not have infinite resources; increasing human consumption places severe stress on the natural processes that renew some resources, and depletes those resources that cannot be renewed.

Humans use many natural systems as resources. Natural systems have the capacity to reuse waste but that capacity is limited. Natural systems can change to an extent that exceeds the limits of organisms to adapt naturally or humans to adapt technologically.

Environmental Quality

Natural ecosystems provide an array of basic processes that affect humans. Those processes include maintenance of the quality of the atmosphere, generation of soils, control of the hydrologic cycle, disposal of wastes, and recycling of nutrients. Humans are changing many of these basic processes, and the changes may be detrimental to humans.

Materials from human societies affect both physical and chemical cycles of the earth.

Many factors influence environmental quality. Factors that students might investigate include population growth, resource use, population distribution, overconsumption, the capacity of technology to solve problems, poverty, the role of economic, political, and religious views, and different ways humans view the earth.

Natural and Human-induced Hazards

Natural and human-induced hazards present the need for humans to assess potential danger and risk. Many changes in the environment designed by humans bring benefits to society, as well as cause risks. Students should understand the costs and trade-offs of various hazards—ranging from those with minor risk to a few people to major catastrophes with major risk to many people.

Teacher Guide

OVERVIEW

Saving Energy at School: Learning & Conserving provides students with comprehensive information on energy consumption, its economic and environmental effects, and energy conservation and efficiency through a series of activities that involve hands-on learning, monitoring energy use, and changing behaviors. There are separate guides for each activity.

BACKGROUND/SKILLS

Saving Energy at School: Learning & Conserving is a hands-on unit that explores energy consumption and conservation using the local school as a real–world laboratory. The activities encourage the development of cooperative learning, math, science, public speaking, and critical thinking skills.

GRADE LEVEL/TIME

This unit is designed for students in grades 7–12 and will take approximately seven 45-minute class periods, plus out-of-class research and homework.

PREPARATION

- Familiarize yourself with the **Teacher Guide**, the **Student Guide** and the information for each activity. If you are using the **Learning & Conserving Kit,** familiarize yourself with the equipment. Make sure that you have a working knowledge of the information, definitions, and conversions, and how to operate the equipment.
- Make copies of the pages from the **Student Guide** that you want to students to complete, if you don't want them writing in the guides. It is suggested that students keep journals during the unit.

MATERIALS

- 2 Lamps
- 1 Incandescent Bulb
- 1 CFL Bulb
- 2 Kill A Watt™ Monitors
- 1 Light Meter
- 1 Immersion Thermometer
- 1 Indoor/Outdoor Thermometer
- 1 Flicker Checker
- 1 Digital Hygrometer/Thermometer Pen
- 1 Class Set of Student Guides (30)

ADDITIONAL ACTIVITIES & RESOURCES

NEED's **Saving Energy Expo**, **Energy Conservation Contract,** and **School Energy Survey** activities are excellent additional, or substitute, culminating activities. They are available on NEED's website at **www.need.org**.

The data in this curriculum is from the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy (EERE) ***Energy Savers*** website at **www1.eere.energy.gov/consumer/tips/index.html**. This website has additional information, maps, and statistics that the students can use. Copies of the Energy Savers booklet may be obtained by calling the EERE Information Center at 1-877-337-3463.

Answer Keys

Student Guide Pages 11–13: Reading Meters

Pg 11: 1,050 kWh x $0.10/kWh = $105.00

Pg 12: 1,337 CCF = 1,337 therm x $1.34/therm = $1,791.58

Pg 13: 97,421 kWh – 71,565 kWh = 25,856 kWh x $0.10/kWh = $2,585.60/31 = $83.41/day

4,750 CCF – 3,077 CCF = 1,673 CCF x 1.025 therm/CCF = 1,714.83 therm x $1.34/therm = $4,067.13/31 = $131.20/day

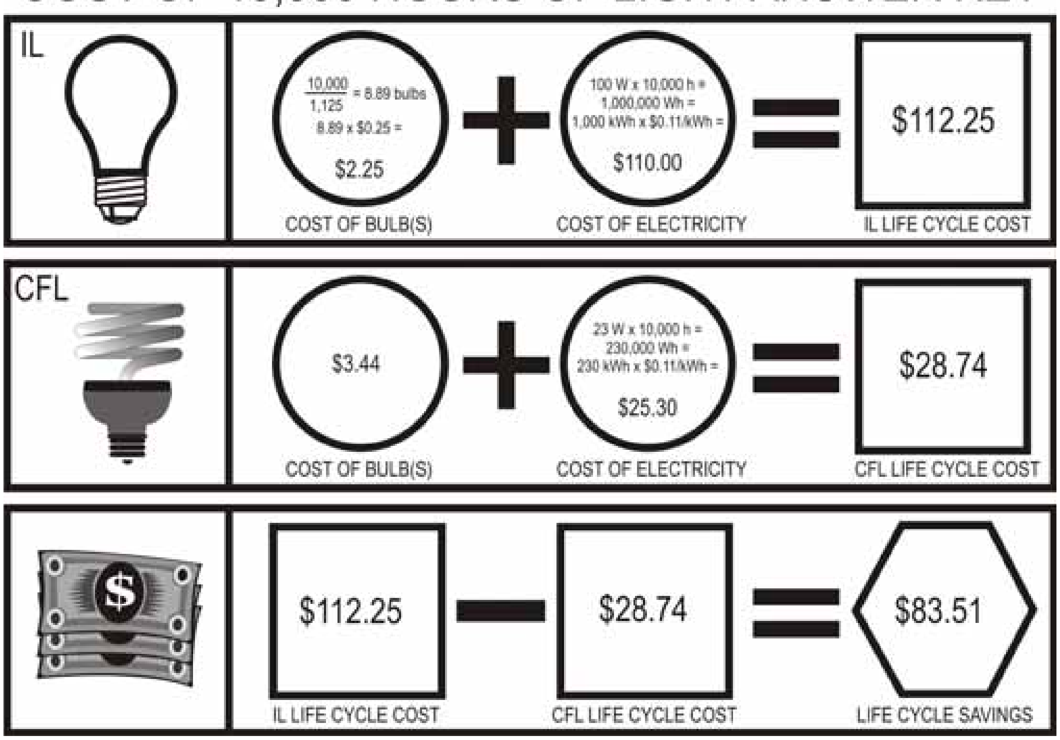
Student Guide Page 21: Comparing Appliances

Water Heater 1: $310 — **Water Heater: $330**

Model 1	Expenses	Cost to Date	Model 2	Expenses	Cost to Date
Purchase Price	310	310	Purchase Price	330	330
Year One	406	716	Year One	397	727
Year Two	406	1,112	Year Two	397	1,124
Year Three	406	1,528	Year Three	397	1,521
Year Four	406	1,934	Year Four	397	1,918
Year Five	406	2,340	Year Five	397	2,315
Year Six	406	2,746	Year Six	397	2,712
Year Seven	406	3,152	Year Seven	397	3,109
Year Eight	406	3,558	Year Eight	397	3,506

Student Guide Page 23: Comparing Lightbulbs

COST OF 10,000 HOURS OF LIGHT ANSWER KEY



Introducing the Unit

Preparation

1. Assign students to topic groups for the Energy Management Plan activity, as follows:

    The Importance of Energy Management

    Building Shell

    HVAC Systems

    Lighting Systems

    Appliances and Plugloads

2. Make copies of the **Topic Group Organizer** (page 36 of the **Student Guide**) if you don't want the students writing in the guides. It is suggested that the students keep science journals during the unit.

Procedure

1. Introduce the unit by asking the class to observe all of the ways energy is being used in the classroom. Make sure that heating/cooling/ventilation, lighting, and powering electrical devices are included in the discussion.
2. Discuss why everyone should be concerned about saving energy—conserving natural resources, economic impacts, and environmental impacts.
3. Ask students to point out ways that energy is wasted in the school.
4. Provide each student with a **Student Guide** and explain the objectives of the unit by reviewing the guide with the students. Explain that the students will complete some of the activities as a class and will be divided into groups to complete other activities.
5. Review the **Energy Definitions and Conversions** on page 10 of the **Student Guide**.
6. Explain the operation of the Kill A Watt Monitor, Hygrometer Pen, and Light Meter (pages 20-22 of the **Teacher Guide**) and demonstrate their use.
7. Give students their topic group assignments and explain that they can be answering their **Topic Group Questions** (page 35 of the **Student Guide**) and completing the **Topic Group Organizer** (page 36 of the **Student Guide**) as they read the backgrounder and complete the classroom activities.
8. Explain to the students that representatives of each topic group will be placed into **Energy Management Plan Groups** as the culminating activity of the unit to complete an Energy Management Plan project. Each plan group will design a project for a different target audience, including the school board, school administration, maintenance staff, PTA, community members, classmates, and younger students. Depending on the target audience assigned, the group will decide upon a project format that will most effectively disseminate the information, such as a PowerPoint presentation, expo, video, brochure, newsletter, etc.
9. Direct the students to the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy (EERE) ***Energy Savers*** website at **www1.eere.energy.gov/consumer/tips/index.html** for more information.

Classroom Activity

Reading Meters & Utility Bills

Overview

These classroom activities teach students how to read electric and natural gas meters, how electricity and natural gas are measured, how to determine the cost of electricity and natural gas, and how to read utility bills.

Background

Schools use a lot of energy to provide students with a comfortable and usable building in which to learn. Educational machines—such as televisions, VCRs, and computers—use energy as well. The two major types of energy used by schools are electricity and natural gas. Many different energy sources are used to generate electricity—both renewables and nonrenewables—but half of the electricity in the U.S. is generated by coal-fired plants.

In schools, electricity is used to provide light, to operate the machines and appliances, to cool the building and, perhaps, for heating, cooking, and hot water heating. Natural gas is used principally to heat buildings, heat water, and for cooking. It can also be used to generate the electricity the school uses. Other fuels that schools might use are heating oil, propane, solar energy, and geothermal energy.

Electricity enters the school through a distribution line that passes through a meter that measures the amount of electricity consumed in kilowatt-hours.

Natural gas enters the school through a pipeline with a meter that measures the volume of natural gas consumed in hundreds of cubic feet, or CCF. The school is billed for the amount of thermal energy in the natural gas—the number of therms that are used—and a conversion factor is recorded on the bill. One CCF of natural gas contains about 100,000 Btu or one **therm** of heat energy. This figure can vary by up to 25 percent depending on the supply. Utility bills list the actual energy content conversion factor.

Concepts

- We can measure the energy we use for lighting, heating, cooling, heating water, and operating appliances.
- Understanding how we use energy and how much energy we use can help us conserve.

Skills

- Math & Measurement
- Critical Thinking

Objectives

- To learn to read electric and natural gas meters.
- To learn how electricity and natural gas are measured and their costs.

Procedure

1. Introduce the activity to the class, discussing the tasks that use electricity and natural gas at home and at school.
2. Have the students complete pages 11–13 of the **Student Guide**. Review with the class.
3. Review the Sample Residential Electric and Gas Bills on pages 14–15 of the **Student Guide**, using the Explanation Key on page 16.

Extension Activity—Monitoring School Electric Meters

Have the students monitor one or all of the school's electric meters for a week and determine how much electricity is used on average each day. Find out the electricity rate for the school and determine the average cost per day for electricity.

Electrical Devices & Their Impacts

Overview

These classroom activities teach students how to read and interpret the energy information on the nameplates of electrical devices, to determine the amount of electricity consumed by those devices over time, and to determine the cost of the electricity used and the amount of carbon dioxide produced by the energy use. Students develop an awareness of school and personal electricity consumption and its effect on the environment.

Background

Electric Nameplates

Every appliance and machine in the United States that uses electricity has a nameplate with the voltage required and the wattage. Sometimes, the current is listed instead of the voltage. If any two of the three measurements are listed, the third can be determined using the following formula: **wattage = current x voltage.**

Often, you will see the letters UL on the nameplate. The UL mark means that samples of the product have been tested to recognized safety standards and have been found to be reasonably free from fire, electric shock, and related safety hazards.

Using the data on the nameplate, the amount of time the appliance is used, and the cost of electricity, you can determine the cost of operating the appliance. To determine the cost to operate an appliance for one hour, use this formula: **cost/h = wattage (kW) x cost/kWh.**

Environmental Effects

CO_2 is a greenhouse gas. Human activities have dramatically increased its concentration in the atmosphere. Since 1800, the level of CO_2 in the atmosphere has increased about 30 percent. Generating electricity accounts for a large portion of CO_2 emissions in the U.S. Some electricity generation—such as hydropower, solar, wind, geothermal, and nuclear—doesn't produce carbon dioxide because no fuel is burned.

Almost half of the nation's electricity, however, comes from burning coal. Another 23.8 percent comes from burning natural gas, petroleum and biomass. There is a direct correlation between the amount of electricity we use and the amount of CO_2 emitted into the atmosphere. The rule of thumb is that generating a kilowatt-hour (kWh) of electricity produces 1.6 pounds of CO_2, which is emitted into the atmosphere.

Concepts

- The electrical appliances and machines we use consume a lot of energy and affect the environment.
- We can determine the amount of electricity that appliances use, the cost, and the amount of CO_2 emitted.

Skills

- Math & Measurement
- Comparison & Contrast
- Critical Thinking

Objectives

- To determine the energy requirements and cost of using several electrical appliances.
- To develop an awareness of personal electricity use and its effect on the environment.

Procedure

1. Have the students complete the activities on pages 17–19 of the Student Guide using machines in the classroom. Review with the class.

Classroom Activity

EnergyGuide Labels

Overview

This classroom activity teaches students to read and compare the EnergyGuide labels required on most large appliances—such as refrigerators, furnaces, water heaters, and air conditioners. Students develop an awareness of life cycle cost analysis, payback period, and efficient technologies.

Background

The Federal government requires that appliance manufacturers provide information about the energy efficiency of their products to consumers so that they can compare the life cycle costs of the appliances, as well as the purchase price. The life cycle cost of an appliance is the purchase price plus the operating cost over the projected life of the appliance.

The law requires that manufacturers place EnergyGuide labels on all new refrigerators, freezers, water heaters, dishwashers, clothes washers, room air conditioners, central air conditioners, heat pumps, furnaces and boilers. The EnergyGuide labels list the manufacturer, the model, the capacity, the features, the average amount of energy the appliance will use per year, its comparison with similar models, and the estimated yearly energy cost. For refrigerators, freezers, water heaters, dishwashers, and clothes washers, the labels compare energy consumption in kWh/year or therms/year. For room air conditioners, central air conditioners, heat pumps, furnaces and boilers, the rating is not in terms of energy consumption, but in energy efficiency ratings, as follows:

EER–Energy Efficiency Rating (room air conditioners)
SEER–Seasonal Energy Efficiency Rating (central air conditioners)
HSPF–Heating Season Performance Factor (with **SEER**–heat pumps)
AFUE–Annual Fuel Utilization Efficiency (furnaces and boilers)

The estimated annual operating cost is based on recent national average prices of electricity and/or natural gas and assumes typical operating behavior. For example, the cost for clothes washers assumes a typical washer would be used to wash eight loads of laundry per week.

Concepts

- Some appliances are more energy efficient than others.
- The energy efficiency of major appliances can be quantified.
- The federal government requires that most major appliances carry labels to inform consumers of their energy efficiency ratings.
- Efficient appliances are usually more expensive to buy than less efficient models, but the life cycle cost of efficient appliances is usually much less than the less expensive appliances.
- Payback period is the operating time for an energy efficient appliance before the higher up-front (purchase) cost is recouped by lower energy costs.

Skills

- Comparison & Contrast
- Math
- Critical Thinking

Objectives

- To learn how to read and understand the information on EnergyGuide labels.
- To compare the life cycle costs and payback period of two similar appliances using the information on the EnergyGuide labels.

Procedure

1. Have the students read about **EnergyGuide Labels** on page 20 of the **Student Guide**.
2. Have the students complete the **Comparing Appliances** activity on page 21 of the **Student Guide**. Review with the students, emphasizing the payback period and energy savings in subsequent years.

Classroom Activity

Facts of Light

Overview

This classroom activity teaches students how to compare the energy-related properties of different types of lightbulbs. Students develop an awareness and understanding of life cycle cost analysis.

Background

Lighting accounts for a significant portion of the electricity used in the United States. In commercial buildings, 20 percent of the total energy bill is for lighting and, in homes, about ten percent. Most of the light in residences is produced by incandescent lightbulbs. These bulbs are surprisingly inefficient, converting up to 90 percent of the electricity into heat instead of light. If we converted to efficient lighting technologies, the electricity consumed would be reduced by 70 percent. Reducing the electricity used for lighting by just one percent would eliminate the need for an average-sized power plant.

Recent developments have resulted in compact fluorescent lights (CFLs) that are four times as efficient as incandescent bulbs and last up to 13 times longer. Over the life of the bulbs, CFLs cost the average consumer less than half the cost of traditional incandescent bulbs for the same amount of light. In addition, CFLs produce very little heat, reducing the need for air conditioning in warm weather.

Most schools and commercial buildings use fluorescent lighting. There are different fluorescent systems available. New fluorescent lighting systems are much more efficient than earlier lights and provide more natural light.

Concepts

- Lighting consumes a significant amount of energy.
- New technologies in lighting can reduce energy consumption.
- Life cycle costs should be considered in lighting decisions, not just purchase price.

Skills

- Math & Measurement
- Comparison & Contrast
- Critical Thinking
- Using Technology to Gather Data

Objectives

- To compare the energy consumption of incandescent and compact fluorescent bulbs.
- To develop an awareness and understanding of life cycle cost analysis.

Procedure

1. Have the students read the **Facts of Light** on page 22 of the **Student Guide**.
2. Have the students complete the **Comparing Lightbulbs** activity on page 23 of the **Student Guide**. Review with the students, emphasizing the difference between purchase price and life cycle cost.

Extension

Have the students develop a marketing plan to convince people to use CFLs. Students can make posters, flyers, radio announcements, and television infomercials to explain the benefits of using CFLs.

Investigating Plugloads

Overview

These activities teach students how to use a Kill A Watt Monitor to measure and monitor the electric power consumption of electrical machines and devices in the school. Students in the Appliances and Plugloads Topic Group conduct the activities for the class.

Concepts

- The electrical devices and machines we use consume energy.
- We can monitor the amount of electricity that machines use and calculate the cost.
- Some machines use more electricity in active mode than in idle mode.
- We can monitor the difference in electricity usage between active and idle modes and calculate the cost.
- Some machines use electricity even when they are turned off.
- We can monitor the electricity usage of machines that are turned off and calculate the cost.

Skills

- Using Technology to Gather Data
- Math, Measurement, and Estimation
- Comparison & Contrast
- Critical Thinking

Objectives

- To learn how to use a Kill A Watt Monitor to gather electrical consumption data.
- To gather electric consumption data from a variety of electrical devices in the school in active and idle modes, as well as when they are turned off and calculate the cost of using them.

Materials

- Kill A Watt Monitor

Preparation

- Make student copies as required.

Procedure

1. Have the **Appliances and Plugloads Topic Group** conduct the activities on pages 24-27 of the **Student Guide** as classroom demonstrations.
2. Have all students record the results in their journals.

Investigating Lighting

Overview

In these activities, students compare incandescent and compact fluorescent bulbs and learn how to use a Light Meter and Flicker Checker to measure and monitor the light levels in the school. Students in the Lighting Topic Group conduct the activities for the class.

Concepts

- Lighting consumes a significant amount of energy.
- New technologies in lighting can reduce energy consumption.
- Lightbulbs produce heat as well as light.
- We can use technologies to measure the energy consumed and light output of lightbulbs.

Skills

- Math & Measurement
- Comparison & Contrast
- Critical Thinking
- Using Technology to Gather Data

Objectives

- To compare the heat output of incandescent and compact fluorescent lightbulbs.
- To compare the light output of incandescent and compact fluorescent bulbs.
- To compare the energy consumption of incandescent and compact fluorescent bulbs.
- To investigate light levels in the school using a light meter.
- To determine the type of lighting in different areas of the school using a Flicker Checker.

Materials

- Kill A Watt Monitor
- Light Meter
- 1 Incandescent Bulb
- 1 Compact Fluorescent Bulb
- 2 Lamps
- 1 Flicker Checker

Preparation

- Make student copies as required.

Procedure

1. Have the **Lighting Topic Group** conduct the activities on pages 28–34 of the **Student Guide** as classroom demonstrations.
2. Have all students record the results in their journals.
3. Have the students answer the Lighting section questions of the **School Building Survey** (page 39).

School Building Survey

Overview

In this activity, students in their topic groups investigate the construction of their school, the fuels the school uses to meet its energy needs, the amount of energy the school uses, and the ways that the school's energy consumption is managed and controlled.

Background

When an energy survey of a building is conducted, four main areas are included:

Building Envelope: The building envelope is the physical structure—the walls, windows, roof, doors, floor, stairwells, ceiling and insulation. The design and construction of the building envelope is a major factor in heating, cooling, and lighting costs.

Heating/Cooling Systems: Heating and cooling the building is the largest single expense of the school. Most schools are heated with natural gas, some with electricity or heating oil. Electricity is usually used for cooling. Maintenance and temperature control of these systems makes a significant impact on energy costs.

Water Heating: Water heaters provide hot water for classrooms, lavatories, showers, laboratories, snack bars, and kitchens. They are usually fueled by natural gas or electricity. Insulation, maintenance, and control of temperature and water flow can reduce energy costs for the school.

Lighting: Electricity is used to provide artificial lighting to classrooms, gyms, auditoriums, corridors, offices, sports fields, and parking areas. Maximizing the use of natural light and installing efficient fluorescent lighting systems can significantly reduce energy costs. Controlling light intensity, turning off unnecessary lights, and proper system maintenance can also make an impact on lighting costs for the school.

Concepts

- Schools use a lot of energy to produce a safe, comfortable learning environment. Many factors determine the amount of energy a school uses.
- Schools can reduce energy consumption by upgrading older systems with energy efficient technologies, instituting energy conservation measures, and educating students, administrators, and staff.
- Reducing energy use saves schools money that can be used for other programs and helps protect the environment.

Skills

- Investigation & Research
- Using Technologies to Gather Data
- Data Interpretation
- Critical Thinking
- Presentation

Procedure

1. Assign the Importance of Energy Management Topic Group to answer the General Information questions of the **School Building Survey** (page 38 of the **Student Guide**).
2. Assign the Building Shell Topic Group to investigate and answer the Building Envelope questions of the **School Building Survey** (page 38 of the **Student Guide**).
3. Assign the HVAC Topic Group to investigate and answer the Heating/Cooling Systems and Water Heating questions of the **School Building Survey** (page 39 of the **Student Guide**).
4. Assign the Lighting Topic Group to investigate and answer the Lighting questions of the **School Building Survey** (page 39 of the **Student Guide**).
5. Have all groups give brief reports on their findings and record the results in their journals.

School Energy Use Survey

Overview

In this activity, students investigate the management of the energy consumed in their school. They measure and monitor the temperature and light intensity levels in classrooms, hallways, and other rooms; the temperature of the hot water in different areas of the school, and other controls, management, and behaviors that affect energy consumption.

Background

Even if school buildings are well insulated and have the most modern, efficient energy systems, a significant amount of energy can be wasted if these systems are not controlled and managed wisely. The best heating system in the world cannot operate efficiently if outside doors or windows are left open, or if the temperature is not controlled. The same is true for cooling systems. Temperature control systems should be set at 68°F during the heating season and 78°F during the cooling season during the day, and at 55°F (heating season) and 85°F (cooling season) during the night for optimum efficiency. Programmable thermostats—with access limited to authorized personnel—are recommended. There should also be policies regarding the opening of windows and doors during heating and cooling seasons.

If the temperature of rooms can be individually controlled, there should be policies on permissible temperature ranges. These ranges can vary for different rooms—gyms, for example, need not be heated to the same temperature as classrooms, when physical activity is scheduled. Auditoriums, hallways, storage rooms, and other little used rooms need not be heated and cooled to the same temperature as occupied rooms.

Lighting—even the most efficient fluorescent system—is not efficient if it is used indiscriminately. In most schools, more light is used than is necessary. Maximum use of natural lighting should be encouraged and dimmer switches should be used whenever possible. All lights that are not necessary for safety should be turned off when rooms are not in use. The same is true for outside lights.

Water heaters should be equipped with timers and temperature settings regulated according to task. Washing hands does not require water as hot as washing dishes. Most water heaters are set much higher than necessary for the task.

Plugloads consume a significant amount of energy in a typical school. Many machines are left on all the time. Other machines consume energy even when they are turned off.

Concept

Schools can significantly reduce energy costs by using energy efficient technologies and monitoring and managing energy consumption through behavioral changes.

Skills

- Investigation & Research
- Data Analysis
- Presentation
- Record Keeping
- Critical Thinking

Objective

To conduct a survey of the school's energy consumption.

Materials

- Light Meter
- Digital Waterproof Thermometer
- Indoor/Outdoor Thermometer
- Digital Pocket Thermometer/Hygrometer
- Flicker Checker

Preparation

1. Arrange for the school district's energy manager to speak to the class about what is being done in the district to conserve energy.
2. Obtain permission for the students to survey classrooms and non-class areas of the school building.
3. Choose several classrooms and non-class areas for the students to survey, including upstairs and downstairs rooms and rooms on different sides of the building.
4. Install the indoor/outdoor thermometer in a classroom window.
5. Form groups of students with at least one representative of each topic group. These groups—the **Plan Groups**—will compile the data for the recording forms, then work together to combine their knowledge and information into an energy management plan in the culminating activity.
6. Make copies of the **Recording Forms 1 & 2** on pages 41-42 of the **Student Guide** for each group.
7. Make additional copies of the **Topic Group Organizer** for each student.

Procedure

1. Have the students read **School Energy Consumption** on page 40 of the **Student Guide** and brainstorm a list of questions for the energy manager.
2. Have the energy manager make a presentation to the students and answer their questions.
3. Explain to the students that they will be surveying areas of the school in groups that will include all of the topic groups, then review the Daily Recording Forms 1 & 2 on pages 41-42 of the **Student Guide** to inform them of the information they will be gathering and the tools they will be using.
4. Assign students to their groups and explain that each group will have 10-15 minutes to conduct its survey.
5. Assign each group to one classroom and one non-class area.
6. Demonstrate how to operate the digital waterproof thermometer, and the digital pocket hygrometer/thermometer, if necessary.

   Note: Only the Digital Waterproof Thermometer can be used for measuring the temperature of water. The Digital Hygrometer/Thermometer can only be used to measure air temperature.
7. Allow each group 10-15 minutes to collect the data on their **Recording Forms**.
8. Have the students analyze the results, looking for explanations of variations. Is it hotter on the south side of the building or in upstairs rooms?
9. Have the students record the information gathered in their journals.
10. Have the topic groups meet to compare and add information to their **Topic Group Organizers** and complete the questions on their sections of the **School Building Survey** and **School Energy Use Survey**.

Energy Management Plan Project

Overview

In this activity, student groups incorporate the information and data they have accumulated into an energy management plan to reduce energy consumption in the school.

Concept

Schools can significantly reduce energy costs by using energy efficient technologies and monitoring and managing energy consumption.

Skills

- Investigation & Research
- Data Analysis
- Presentation
- Record Keeping
- Critical Thinking

Objective

To develop a comprehensive energy management plan for the school.

Preparation

1. Make copies of the **Energy Management Plan Organizer** on page 37 of the **Student Guide** for the students.
2. Decide what acceptable types of presentations you want the groups to design (PowerPoint, formal project, informative project for administrators, persuasive project for fellow students, video, brochure, newsletter, action plan, etc.) and the timeframe for completion of the projects.

Procedure

1. Explain to the students that they will work in their plan groups to develop an energy management plan for the school using the information and data they have gathered. Direct them to the **Plan Organizer** on page 37 of the **Student Guide** for them to use to organize and prioritize their information.
2. Assign each plan group a **Target Audience** for its project, such as:

   School Board | **Community Members**
   School Administration | **Family Members**
   Maintenance Staff | **Younger Students**
   Fellow Students | **PTA**

3. Provide the students with the presentation parameters and timeframe. Emphasize that the presentations should include information from all of the topic groups and be appropriate for the target audience.
4. Have the groups meet to formulate their action plans. If desired, have the groups present their action plans to you for approval before proceeding.
5. Arrange for the groups to make their presentations to the class or to their target audiences, if possible.
6. Evaluate the projects using the **Grading Rubric** on the next page.

GRADING RUBRIC—PRESENTATION PROJECT

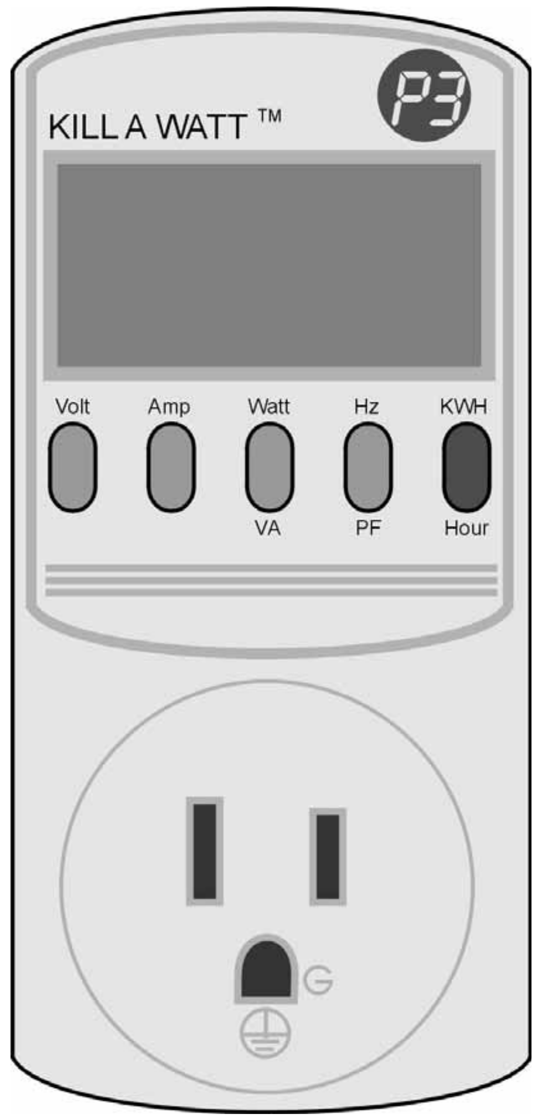
Grade	Content	Organization	Originality	Workload
4	Project covers the topic in-depth with many details and examples. Subject knowledge is excellent. Understanding of target audience is excellent.	Content is very well organized and presented in a logical sequence.	Project shows much original thought. Ideas are creative and inventive.	The workload is divided and shared equally by all members of the group.
3	Project includes essential information about the topic. Subject knowledge is good. Understanding of target audience is good.	Content is logically organized.	Project shows some original thought. Work shows new ideas and insights.	The workload is divided and shared fairly equally by all group members, but workloads may vary.
2	Project includes essential information about the topic, but there are 1-2 factual errors. Understanding of target audience is fair.	Content is logically organized with a few confusing sections.	Project provides essential information, but there is little evidence of original thinking.	The workload is divided, but one person in the group is viewed as not doing fair share of the work.
1	Project includes minimal information or there are several factual errors. Understanding of target audience is poor.	There is no clear organizational structure, just a compilation of facts.	Project provides some essential information, but no original thought.	The workload is not divided, or several members are not doing fair share of the work.

Kill A Watt™ Monitor

The Kill A Watt™ monitor allows users to measure and monitor the power consumption of any standard electrical device. You can obtain instantaneous readings of voltage (volts), current (amps), line frequency (Hz), and electrical power being used (watts). You can also obtain the actual amount of power consumed in kilowatt-hours (kWh) by any electrical device over a period of time from 1 minute to 9,999 hours. One kilowatt equals 1,000 watts.

OPERATING INSTRUCTIONS

1. Plug the Kill A Watt monitor into any standard grounded outlet or extension cord.
2. Plug the electrical device or appliance to be tested into the **AC Power Outlet Receptacle** of the Kill A Watt™ monitor.
3. The **LCD** displays all monitor readings. The unit will begin to accumulate data and powered duration time as soon as the power is applied.
4. Press the **Volt** button to display the voltage (volts) reading.
5. Press the **Amp** button to display the current (amps) reading.
6. The **Watt** and **VA** button is a toggle function key. Press the button once to display the Watt reading; press the button again to display the VA (volts x amps) reading. The Watt reading, not the VA reading, is the value used to calculate kWh consumption.
7. The **Hz** and **PF** button is a toggle function key. Press the button once to display the Frequency (Hz) reading; press the button again to display the Power Factor (PF) reading.
8. The **KWH** and **Hour** button is a toggle function key. Press the button once to display the cumulative energy consumption. Press the button again to display the cumulative time elapsed since power was applied.

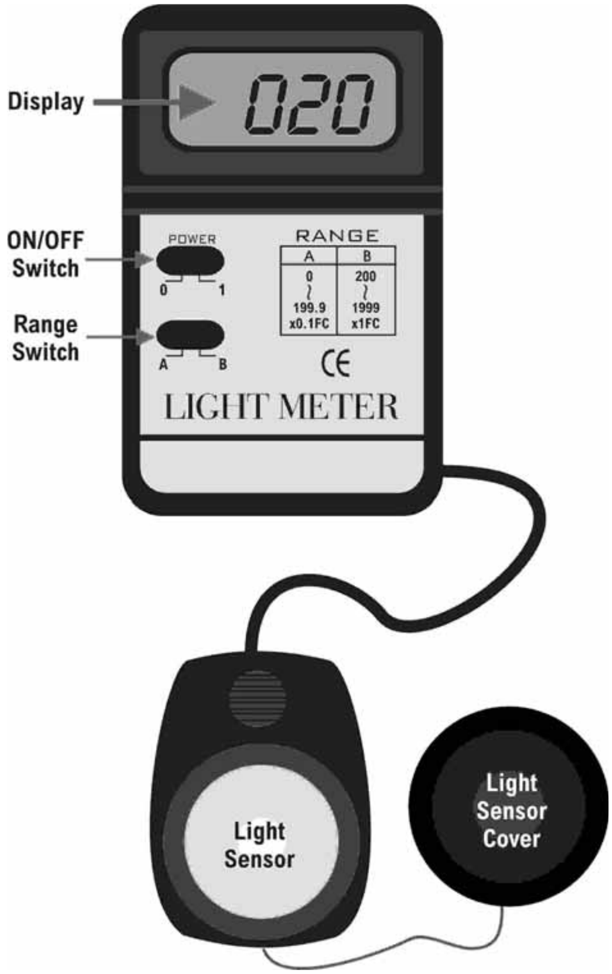


WHAT IS POWER FACTOR (PF)?

We often use the formula **Volts x Amps = Watts** to find the energy consumption of a device. Many AC devices, however, such as motors and magnetic ballasts, do not use all of the power provided to them. The Power Factor (PF) has a value equal to or less than one, and is used to account for this phenomenon. To determine the actual power consumed by a device, the following formula is used:

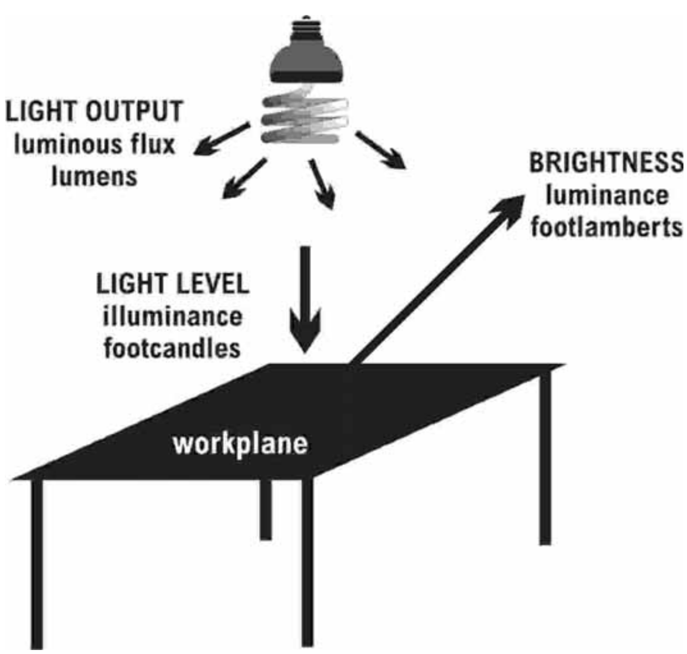
VOLTS X AMPS X PF = WATTS CONSUMED

The Light Meter



OPERATING INSTRUCTIONS

1. Insert the battery into the battery compartment in the back of the meter.
2. Slide the ON/OFF Switch to the ON position.
3. Slide the Range Switch to the B position.
4. On the back of the meter, pull out the meter's tilt stand and place the meter on a flat surface in the area you plan to measure.
5. Hold the Light Sensor so that the white lens faces the light source to be measured or place the Light Sensor on a flat surface facing the direction of the light source.
6. Read the measurement on the LCD Display.
7. If the reading is less than 200 fc, slide the Range Switch to the A position and measure again.



LIGHT OUTPUT OR LUMINOUS FLUX

A lumen (lm) is a measure of the light output (or *luminous flux*) of a light source (bulb or tube). Light sources are labeled with output ratings in lumens. A T-12 40-watt fluorescent tube light, for example, may have a rating of 3050 lumens.

LIGHT LEVEL OR ILLUMINANCE

A footcandle (fc) is a measure of the quantity of light (illuminance) that actually reaches the workplane on which the light meter is placed. Footcandles are *workplane lumens per square foot*. The light meter can measure the quantity of light from 0 to 1000 fc.

BRIGHTNESS OR LUMINANCE

Another measure of light is its brightness or *luminance*. Brightness is a measure of the light that is reflected from a surface in a particular direction. Brightness is measured in footlamberts (fL).

Hygrometer/Thermometer Pen

Scientists measure the amount of water vapor in the air in terms of relative humidity—the amount of water vapor in the air relative to (compared to) the maximum amount it can hold at that temperature. Relative humidity changes as air temperature changes. The warmer the air is, the more water vapor it can hold.

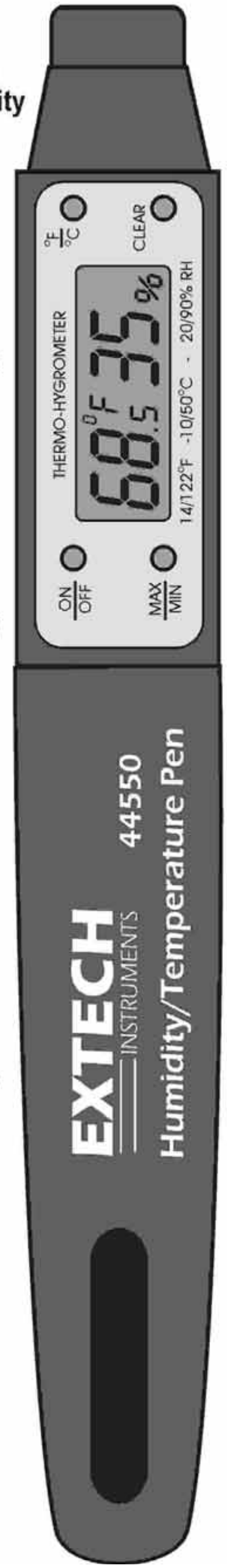
Air acts like a sponge and absorbs water through the process of evaporation. Warm air is less dense and the molecules are further apart, allowing more moisture between them. Cooler air causes the air molecules to draw closer together, limiting the amount of water the air can hold.

It is important to control humidity in occupied spaces. Humidity levels that are too high can contribute to the growth and spread of unhealthy biological pollutants. This can lead to a variety of health effects, from common allergic reactions to asthma attacks and other health problems. Humidity levels that are too low can contribute to irritated mucous membranes, dry eyes, and sinus discomfort.

This digital hygrometer/thermometer measures relative humidity and temperature and displays the readings on its face. It has a battery for power. It can display the temperature in Fahrenheit or Celsius. The reading shown on the right is 68.5°F.

The hygrometer displays relative humidity in terms of percentage. The hygrometer shown reads 35%. This means that the air contains 35 percent of the water vapor it can hold at the given air temperature. When the air contains a lot of water vapor, the weather is described as humid. If the air cannot carry any more water vapor, the humidity is 100 percent. At this point, the water vapor condenses into liquid water.

Maintaining relative humidity between 40 and 60% helps control mold. Maintaining relative humidity levels within recommended ranges is a way of ensuring that a building's occupants are both comfortable and healthy. High humidity is uncomfortable for many people. It is difficult for the body to cool down in high humidity because sweat cannot evaporate into the air.



ON/OFF KEY

Press the on/off key to turn the power on or off.

°C/°F

Press the °C/°F key to select the temperature unit you want to use - Celsius or Fahrenheit.

MAX/MIN

Press the MAX/MIN key once to display the stored maximum readings for temperature and humidity. An up arrow ▲ will appear on the left side of the display to indicate the unit is in the maximum recording mode.

Press the MAX/Min key a second time to display the stored minimum readings for temperature and humidity. A down arrow ▼ will appear on the left side of the display to indicate the unit is in the minimum recording mode.

Press the MAX/MIN key a third time to return to normal operation.

CLEAR

If an up or down arrow is displayed, press the CLEAR key until - - - appears on the display. The memory is cleared. New maximum or minimum values will be recorded within 3 seconds.

LEARNING & CONSERVING

Evaluation Form

State: ___________ **Grade Level:** ___________ **Number of Students:** __________

		Yes	No
1.	Did you conduct all of the activities?	Yes	No
2.	Were the instructions clear and easy to follow?	Yes	No
3.	Did the activities meet your academic objectives?	Yes	No
4.	Was the activities age appropriate?	Yes	No
5.	Were the allotted times sufficient to conduct the activities?	Yes	No
6.	Were the activities easy to use?	Yes	No
7.	Was the preparation required acceptable for the activities?	Yes	No
8.	Were the students interested and motivated?	Yes	No
9.	Was the energy knowledge content age appropriate?	Yes	No
10.	Would you use the activities again?	Yes	No

How would you rate the activities overall (excellent, good, fair, poor)?

How would your students rate the activities overall (excellent, good, fair, poor)?

What would make the activities more useful to you?

Other Comments:

Please fax or mail to:

NEED Project
PO Box 10101
Manassas, VA 20108
FAX: 1-800-847-1820

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National Association of State Energy Officials
National Association of State Universities and Land Grant Colleges
National Hydropower Association
National Ocean Industries Association
National Renewable Energy Laboratory
Nebraska Public Power District
New Jersey Department of Environmental Protection
New York Power Authority
New Mexico Oil Corporation
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